

## Two new species in the phyllophorid genus *Massinium* (Echinodermata: Holothuroidea) with redescription of *Massinium magnum*

YVES SAMYN<sup>1,4</sup>, AHMED S. THANDAR<sup>2</sup> & D. VANDENSPIEGEL<sup>3</sup>

<sup>1</sup>*Belgian National Focal Point to the Global Taxonomy Initiative, Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium*

<sup>2</sup>*School of Biological and Conservation Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban 4000, Republic of South Africa*

<sup>3</sup>*Department of Invertebrates, Royal Museum for Central Africa, Leuvensesteenweg 13, B-3080 Tervuren, Belgium*

<sup>4</sup>*Corresponding author. E-mail: yves.samyn@naturalsciences.be*

### Abstract

The recently erected phyllophorid genus *Massinium* Samyn & Thandar, 2003 hitherto held three species: the southern African endemics *Massinium arthropprocessum* (Thandar, 1989) and *M. maculosum* Samyn & Thandar, 2003 (type species), and the central Indo-Pacific *M. magnum* (Ludwig, 1882). Careful examination of the incomplete holotype of *M. magnum* and material assigned to this species from various museums allowed us to completely redescribe the type, supplement the description with information from entire voucher specimens, and recognise two species new to science, previously assigned to *M. magnum*. In addition, the diagnosis of *Massinium* is amended to also include *Neothysonidium dissimilis* Cherbonnier, 1988 from Madagascar. The six currently recognised congenerics are keyed.

**Key words:** taxonomy, Indo-Pacific, sea cucumbers, Phyllophoridae, *Massinium*, new species, new combination

### Introduction

Samyn & Thandar (2003) recently erected the genus *Massinium* to accommodate those species of *Neothysonidium* Deichmann, 1938 which have the posterior processes of their tubular calcareous ring distally joined to form a ring-like structure around the oesophagus and body wall devoid of table ossicles. They included three species in the genus: the southern African endemics *Massinium arthropprocessum* (Thandar, 1989) and *M. maculosum* Samyn & Thandar, 2003 [type species by original designation], and the central Indo-Pacific *M. magnum* (Ludwig, 1882).

*Massinium arthropprocessum* and *M. maculosum* are well described (Thandar 1989; 1996; Samyn & Thandar 2003), but the original description of *M. magnum* is incomplete and lacks illustrations, since it was based solely on the tentacle crown, the introvert and the calcareous ring and its associated structures (Ludwig 1882; 1889-92; see also Lampert 1885 and Théel 1886), rendering its identity open to various interpretations. Sluiter (1901) and Domantay (1933) were the first to have access to complete specimens of *M. magnum* and thus were better able to describe the complete morphology of the species. Later, Cherbonnier (1980; see also Féral & Cherbonnier 1986), after study of the holotype and Sluiter's (1901) ossicle slides, referred his New Caledonian material to *M. magnum*, and Massin (1999; 2005) did the same with material from Sulawesi, Indonesia and Papua, New Guinea.

We re-examined the holotype of *M. magnum* and provide a complete re-description. We also studied Sluiter's, Cherbonnier's, Massin's and other voucher material from the Australian Museum, Sydney, and conclude that two species new to science be recognised in the genus: one endemic to New Caledonia and another endemic to Queensland. Furthermore, we re-examined *N. dissimilis* Cherbonnier, 1988 from Madagascar and find that the structure of its calcareous ring is characteristic of *Massinium* and hence transfer the species to this genus (see fig. 11).

Finally, we here amende the diagnosis of *Massinium* because we observe that both *M. dissimilis* and some individuals of *M. magnum* do present table ossicles in the body wall, though rudimentary in the latter species.

## Materials and methods

Specimens were obtained from the Australian and various European Museums (acronyms in appendix). They were studied according to conventional methods outlined by workers such as Rowe & Doty (1977) and Massin (1999). Ossicles were removed in household bleach, washed in two changes of distilled water and illustrated with the camera lucida. For scanning electron microscopy, samples were dried and mounted on aluminium stubs, coated with gold in a sputter-coater and observed with a JEOL JSM-5400LV scanning electron microscope.

## Systematic account

### Family Phyllophoridae Oestergren, 1907

#### Subfamily Semperiellinae Heding & Panning, 1954

#### Genus *Massinium* Samyn & Thandar, 2003

**Diagnosis (after Samyn & Thandar, 2003, here amended).** A genus of dendrochirotid holothuroids with twenty tentacles arranged in two circles of 10 + 10; anus usually encircled by calcareous teeth; calcareous ring elongate, tubular, with both radial and interradial plates fragmented into a mosaic of small pieces and prolonged posteriorly, with the posterior processes distally linked to processes of neighbouring plates forming a loop beneath the water vascular ring; Polian vesicles elongate, usually four; ossicles of body wall comprise granuliform rods and/or rosette-shaped deposits, tables present in juvenile or occasionally in adults as scarce, reduced deposits.

**Type species:** *Massinium maculosum* Samyn & Thandar 2003 (by original designation)

**Remarks.** The diagnosis of *Massinium* is here amended to also include *Neothyonidium dissimilis* Cherbonnier, 1988 from Madagascar. Re-examination of the holotype of the latter species revealed that its calcareous ring is inaccurately illustrated (cf. Cherbonnier 1988: 213, fig 92N) and that its structure satisfies the diagnosis of *Massinium* (see fig. 11). Therefore, *N. dissimilis* is here transferred to *Massinium*. However, *M. dissimilis* also has scarce table deposits in the body wall (cf. Cherbonnier 1988: 212, 213: fig 92A-G), reported as absent in the original diagnosis of the genus. Scarce, reduced, table-like deposits are also present in Sluiter's (1901) complete specimens of *M. magnum* from Indonesia. As such, we amend the diagnosis of *Massinium* to also accommodate those species with table deposits in their body wall.

Since we think that the only existing specimen of *M. dissimilis* is a juvenile, we regard the presence of body wall tables as a juvenile feature that may persist as scarce, reduced deposits in adults of some species of *Massinium*, as in *M. magnum*.

#### Key to the species of the genus *Massinium*

1. Body wall with rosettes, pseudobuttons *and* scarce tables ..... 2
- 1'. Body wall with various types of deposits, but *never* tables ..... 3
2. Tentacles with tables and rosettes ..... *Massinium dissimilis* (Cherbonnier, 1988)
- 2'. Tentacles with rosettes only ..... *Massinium magnum* (Ludwig, 1882)
3. Body wall with pseudobuttons and rods of various form ..... 4
- 3'. Body wall with pseudobuttons and rosettes, but no rods ..... 5

4. Rods of body wall, somewhat U-shaped, up to 110  $\mu\text{m}$  long. With minute, often occluded distal perforations; endemic to South Africa ..... *Massinium arthroprocessum* (Thandar, 1989)
- 4'. Rods up to 105  $\mu\text{m}$  long, often granuliform, only the smallest ones with non-occluded perforations; endemic to Queensland, Australia ..... *Massinium granulosum* sp. nov.
5. Tube feet of introvert with rosettes, tables with disc perforated by four central holes and 1-3 rings of peripheral holes and multilocular plates of various shapes; endemic to New Caledonia ..... *Massinium albicans* sp. nov.
- 5'. Tube feet of introvert with tables with disc perforated by four central holes and one ring of peripheral holes and simple perforated rods, no rosettes; endemic to KwaZulu-Natal, South Africa ..... *Massinium maculosum* Samyn & Thandar, 2003

### ***Massinium magnum* (Ludwig, 1882)**

(figs 1A–E, 2A–H, 3A–N, 4A&B)

*Thyonidium magnum* Ludwig, 1882: 132; Lampert 1885: 170; Théel 1886: 146.

*Phyllophorus magnus*; Ludwig 1889–92: 347; Sluiter 1901: 112; pl. IV, fig. 5, pl. VII, fig. 1a–e; Domantay 1933: 38, pl. 2, fig. 11a–j; Domantay 1936: 399.

*Neothyonidium magnum*; Heding & Panning 1954: 197, fig. 98; Clark & Rowe 1971: 182 (distribution); ? George & George 1987: 246; ? Rowe & Gates 1995: 312 (synonymy); Colin & Arneson 1995: 262, fig 1247; Gosliner *et al.* 1996: 283, fig. 1045; Erhardt & Moosleitner, 1997: 1151, 1152 (colour pictures); Forbes (ed.) *et al.* 1999: 52; Massin 1999: 88, figs 72a–k, 73; ? Lane *et al.* 2000: 491.

*Neothyonidium magnum*; Cherbonnier 1980: 656, fig. 20A–Q; Féral & Cherbonnier 1986: 102, fig. 40T (non *M. magnum*) (= *M. albicans* sp. nov.).

*Thyone perissa* H.L. Clark, 1938: 471, fig. 43; Rowe & Gates 1995: 312 (synonymy).

*Massinium magnum*; Samyn & Thandar 2003: 135, 141, 142 (*passim*).

**Original name:** *Thyonidium magnum* Ludwig, 1882.

**Name-bearing type:** Holotype: NMNH-Leiden 1989 (calcareous ring with attached structures, introvert and tentacles only).

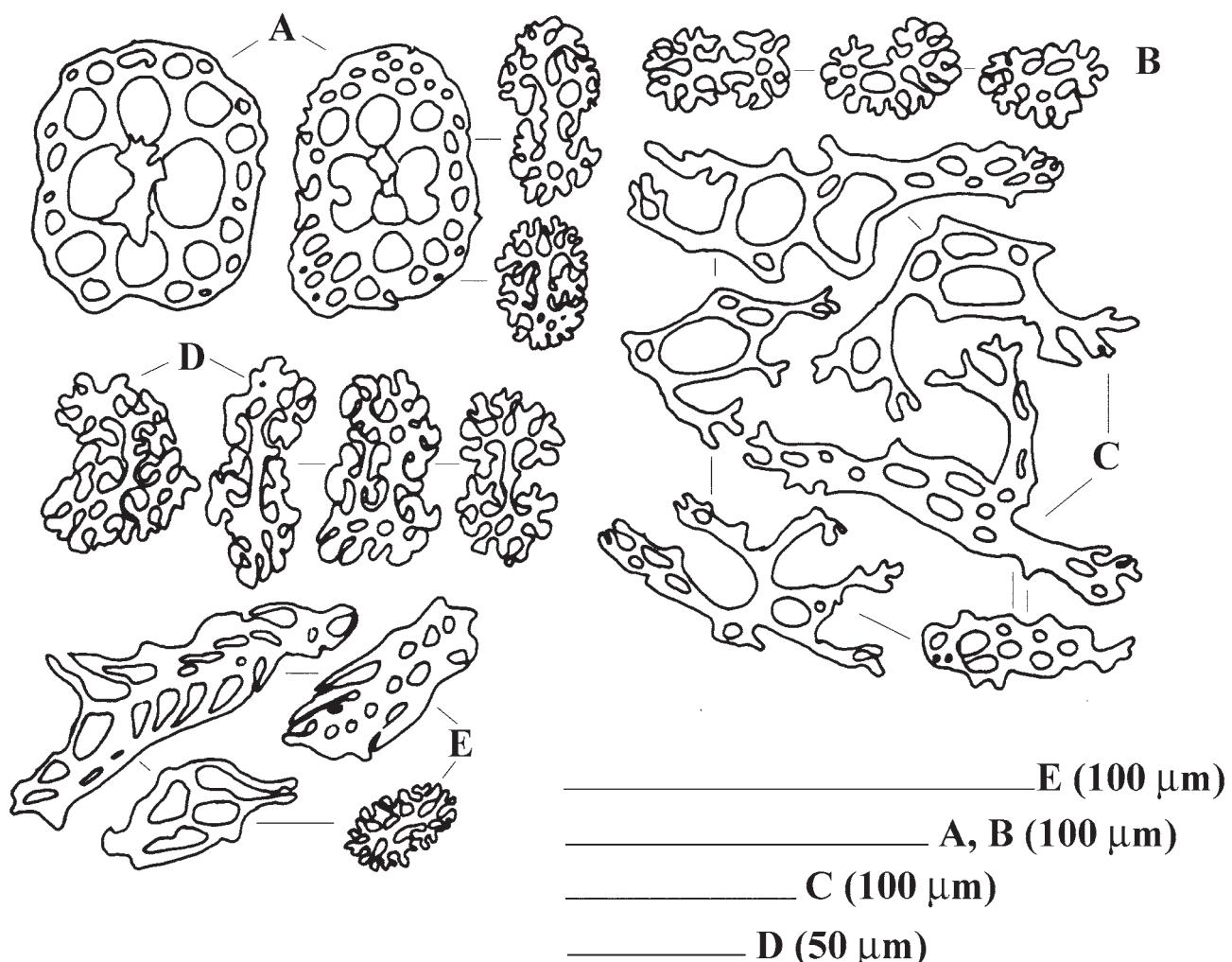
**Type locality:** Ambon, Moluccas, Indonesia.

**Current status:** *Massinium magnum* (Ludwig, 1882).

**Material examined:** NMNH-Leiden 1989 (holotype), Ambon (Moluccas, Indonesia), depth and collection data unknown, coll. E.W.A. Ludeking; ZMUA V.ECH.H.3431 (1 complete specimen), Siboga St. 213, Saleyer Reef (Indonesia), up to 36 m deep, 26.ix.1899, coll. Siboga Expedition; ZMUA 3430 (3 specimens, one complete), Siboga St. 213, Saleyer Reef (Indonesia), up to 36 m deep, 26.ix.1899, coll. Siboga Expedition; IG 28251/169 (calcareous ring and associated structures only), Kudingaieng Keke (SW Sulawesi, Indonesia), 14 m depth, 26.ix.1994, coll. C. Massin; NMNH ECH. 6090 (calcareous ring and associated structures only), Barang Lombo (SW Sulawesi, Indonesia), depth 3 m, 23.ix.1994, coll. C. Massin; IG 28455/51 (calcareous ring and associated structures only), Laing Island (Papua New Guinea), depth 5 m, 16.x.1996, coll. C. Massin; IG 28455/54 (calcareous ring and associated structures only), Laing Island (Papua New Guinea), depth 6 m, 17.x.1996, coll. C. Massin; AM J 13573 (one complete specimen and one calcareous ring and associated structures) (identified as *N. perissum* by F.W.E. Rowe), Heron Island (Queensland, Australia), depth  $\pm$ 12 m, 12.xii.1979, coll. H. Silver; AM J 9490 (calcareous ring and associated structures only), Heron Island (Queensland, Australia), depth 10 m, 21.xi.1974, coll. N. Coleman.

**Holotype description (after Ludwig 1882: 132, amended herein):** Holotype consists of only the calcareous ring with its associated structures; length of complete fragment (excluding tentacles and Polian vesicles) 75 mm. Colour yellowish-brown, tube feet and tentacles darker brown. Mouth encircled by well-developed brownish-white peristomial membrane; tentacles 20, in two distinct circles, outer circle with five pairs of large (25–45 mm) tentacles, alternating with inner circle of five pairs of small (5–7 mm) tentacles; shaft large tentacles pale-brown with one dark banding proximally; tips large tentacles darker brown; shaft small tentacles uniform pale brown; tips small tentacles darker. Tube feet of introvert distributed in two radial rows over most of introvert length, decreasing in size proximally, where they also scatter over interradial areas. Calcareous ring (see Heding & Panning 1954: 197, fig. 98a) 70 mm long, tubular, spirally coiled,

broken into a mosaic of small pieces camouflaged by a thick enveloping membrane; radial and interradial plates fused over about two thirds of length of calacreous ring; radial plates with deep anterior notch, posteriorly prolonged, bifurcating, processes fused with processes of neighbouring radial plates; interradial plates anteriorly pointed. Polian vesicles four, 150–180 mm long, tubular. Stone canal 20 mm long, ending in small truncated madreporite.

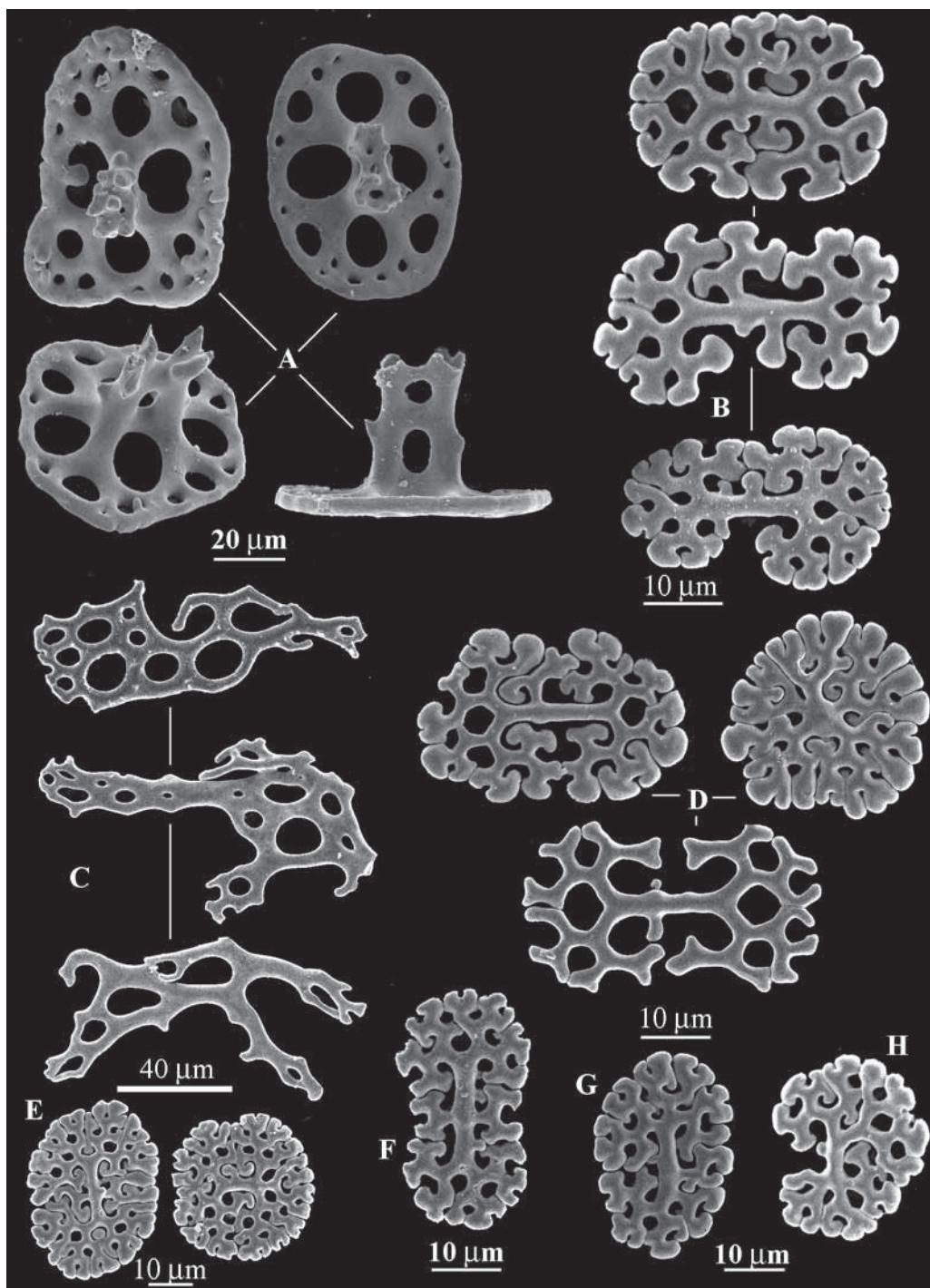


**FIGURE 1.** *Massinium magnum* (Ludwig, 1882), Holotype. A. Tables and scarce rosettes of introvert; B. Rosettes of introvert tube feet; C. Rods of introvert tube feet; D. Rosettes of peristome; E. Lattices and rosette of gonoduct.

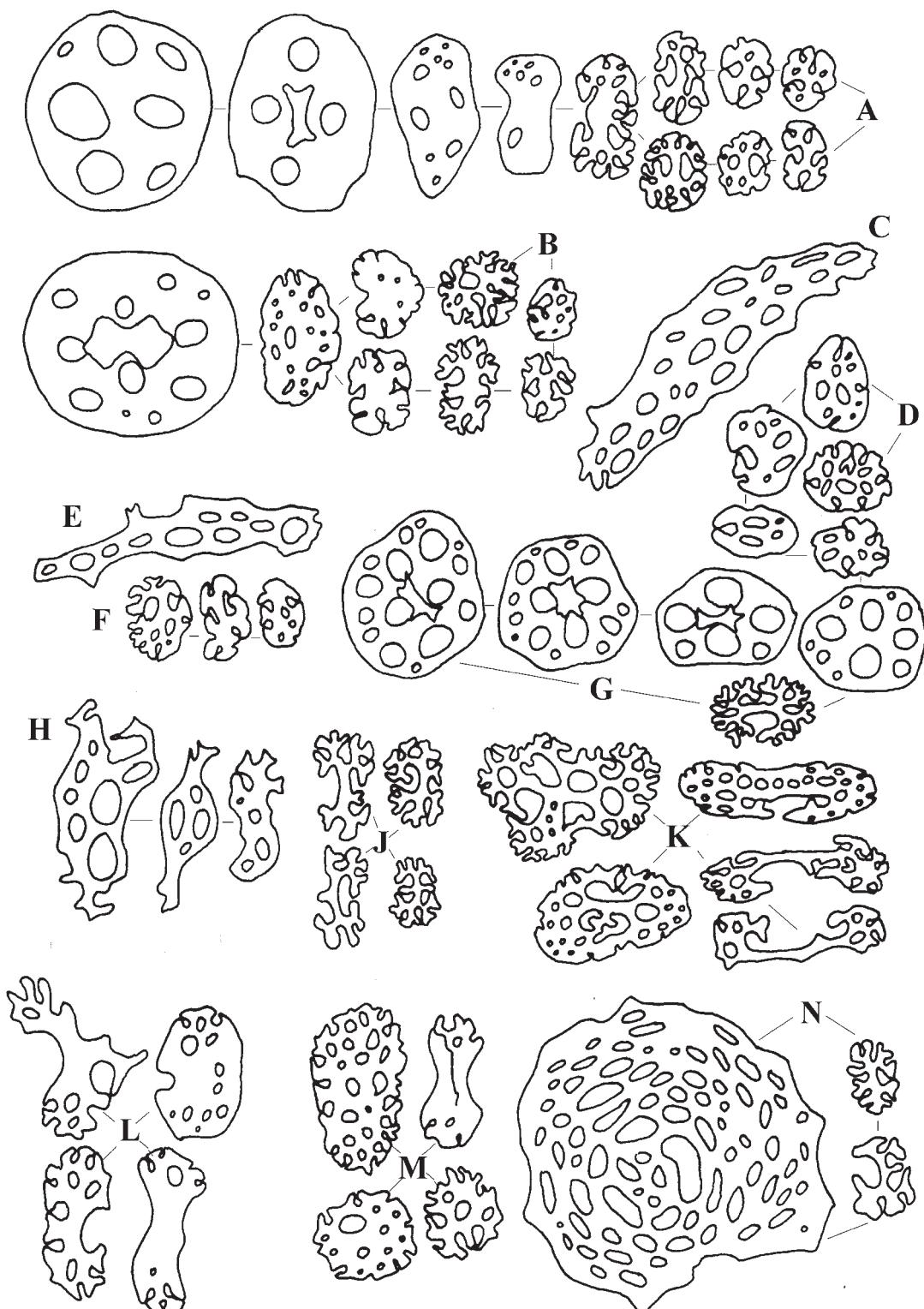
**Ossicle assemblage.** Introvert with tables and scarce rosettes (figs 1A, 2A). Tables with circular to ovoid to irregular disc with smooth rims and perforated by four large central holes and usually a single circle of alternating smaller holes, occasionally two. Table discs 60–80  $\mu\text{m}$  long and 55–60  $\mu\text{m}$  wide; spire low to moderate, of two pillars united by one to two cross-bars, ending in 4–6 tooth-like projections, sometimes subdivided. Rosettes 55–70  $\mu\text{m}$  long. Tube feet of introvert with numerous rosettes (figs 1B, 2B) and perforated irregular rods, sometimes forming plates (figs 1C, 2C). Rosettes 35–45  $\mu\text{m}$  long and 20–40  $\mu\text{m}$  wide, complex with distal endings swollen, not anastamosing. Rods 90–180  $\mu\text{m}$  long, with some large perforations and more smaller ones, ending with irregular branched projections. Peristome with numerous rosettes only (figs 1D, 2D), 30–65  $\mu\text{m}$  long, complex, roundish to elongate, endings distinctly swollen, never anastamosing. Shaft and tips of small and large tentacles with rosettes only, similar in size and shape to those of peristome (figs 2E–H). Longitudinal muscles of introvert devoid of ossicles. Gonoduct with rosettes, 25–30  $\mu\text{m}$  long, and lattice-like deposits, 80–100  $\mu\text{m}$  long (fig. 1E).

**Remarks.** Regrettably, the holotype lacks the main body of the animal and although its description is accurate, it is not accompanied by illustrations. Amongst the subsequent workers who examined the holotype only Heding & Panning (1954) provided a figure of its calcareous ring, but they too did not illustrate the ossicles, apart from two table deposits copied from Domantay (1933). Sluiter (1901) and Domantay (1933) accurately described complete specimens, but failed to illustrate the ossicle assemblage in detail, thus adding to the difficulty in correctly assigning specimens to *M. magnum*.

Therefore, to avoid confusion over the identity of *M. magnum* we have here re-described the type, supplementing it with a description of a complete specimen below.



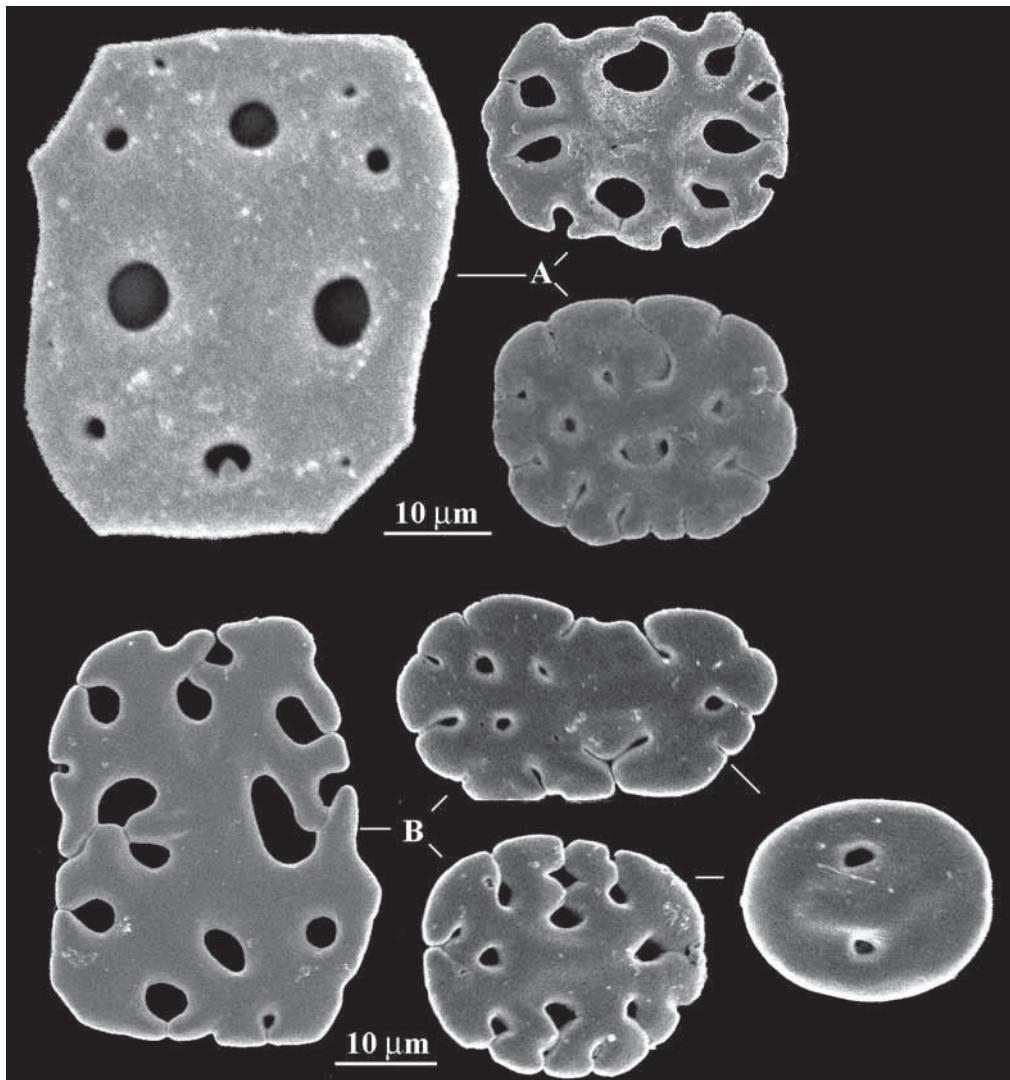
**FIGURE 2.** *Massinium magnum* (Ludwig, 1882), Holotype. A. Tables of introvert; B. Rosettes of introvert tube feet; C. Rods of introvert tube feet; D. Rosettes of peristome; E. Rosettes of shaft of large tentacle; F. Rosette of tip of large tentacle; G. Rosette of shaft of small tentacle; H. Rosette of tip of small tentacle.



**A, B, D, F, J - N (100  $\mu$ m)**

**C, E, H, G (100  $\mu$ m)**

**FIGURE 3** *Massinium magnum* (Ludwig, 1882), non-type material (complete specimen). A. Tables, pseudobuttons and rosettes of ventral body wall; B. Tables, pseudobuttons and rosettes of dorsal body wall; C. Perforated plate of ventral tube feet; D. Pseudobuttons of ventral tube feet; E. Perforated plate of dorsal tube feet; F. Pseudobuttons of dorsal tube feet; G. Tables and rare rosette of introvert; H. Perforated plates of introvert tube feet; J. Rosettes of introvert tube feet; K. Rosettes of peristome; L. Pseudobuttons and irregular rods of longitudinal muscles of body wall; M. Pseudobuttons and irregular rods of cloacal retractor muscles; N. Lattice-like plate and rosettes of gonoduct.



**FIGURE 4.** *Massinium magnum* (Ludwig, 1882), non type material (complete specimen). A. Pseudobuttons and rosettes of ventral body wall; B. Pseudobuttons and rosettes of dorsal body wall.

**Description of complete specimen [ZMUA V.ECH.H.3431]:** Specimen entire, well-preserved. Body wall firm, but not thick (1–4 mm), slightly rough to the touch. Body form cylindrical, U-shaped, slightly contracted. Introvert well-extended, attached to main body by narrow, proximal end. Body length along ventral surface 118 mm, along dorsal surface 90 mm, height of mid-body 60 mm, length of introvert 85 mm, length of constricted proximal part 13 mm. Colouration of body and introvert uniform yellowish-white. Tube feet of body wall yellowish, numerous, retracted, scattered more or less evenly over dorsal and ventral radial and interradial areas, suckers small. Tube feet of introvert brownish, aligned in radial areas in two well-defined rows, except proximally where they also occur in interradial areas, absent in distal 30 mm. Tentacles 19, nine large, 10 small, arranged in two circles; large tentacles in outer circle,  $\pm$  60 mm long, in pairs in radial areas; small tentacles, in inner circle,  $\pm$  10 mm long, in pairs in interradial areas. Tentacles well branched, shaft yellowish-brown, some tentacles slightly banded; branches uniform dark brown. Anus retracted into body, presence or absence of anal teeth not determined. Calcareous ring 80 mm long, tubular, fragmented into a mosaic of small pieces obscured by thick membrane; radial and interradial plates fused over about seven eights of length of calcareous ring; radial plates posteriorly prolonged, bifurcating into processes which fuse with those of neighbouring radial plates. Polian vesicles four, white, 90–120 mm long. Stone canal single, slightly contorted, free, 26 mm long, terminating in small globular madreporite. Introvert retractor muscles thick and short, originating at anterior third of the body.

**Ossicle assemblage.** Body wall with rosettes, pseudobuttons and few tables, mostly reduced (figs 3A,B; 4A,B). Rosettes simple, slightly elongated, 25–40 µm long; pseudobuttons of various shapes, with 2–10 small, randomly placed perforations; tables scarce, reduced to oval, smooth disc, generally with four large central holes and few smaller peripheral ones, occasionally with reduced spire. Tube feet of ventral and dorsal body wall with pseudobuttons, rosettes, elongated perforated plates surrounding endplate (fig 3C–F). Introvert with tables and occasionally rosettes (fig. 3G). Tables with oval, smooth disc, 45–80 µm wide and 75–95 µm long, perforated by four large central holes and usually one, occasionally two, circles of smaller peripheral holes, the larger of these alternating with the central holes, the other arranged more irregularly; spire consisting of two pillars, united by 1–2 cross-bars, terminating in some toothed projections. Tube feet of introvert with rosettes and irregular plates with branched ends (fig. 3H,J). Peristome with only complex rosettes, 50–75 µm long (fig. 3K). Shaft and tips of both large and small tentacles sometimes with few rosettes. Longitudinal muscles of body wall with irregular perforated rods and pseudobuttons (fig. 3L). Longitudinal muscles of introvert devoid of ossicles. Cloacal retractor muscles with irregular deposits (fig 3M). Gonoduct with rosettes and lattice-like plates (fig. 3N).

**Ecology:** Massin (1999: 90) noted ‘...they live deeply buried in sand or coral rubble’ for material from Sulawesi and in 2005 (p. 69) ‘body always buried in sand, only tentacles and introvert visible; tentacles coming out at sunset and at night’ for material from Papua New Guinea.

**Remarks:** The ossicle assemblage of the complete specimen here described (V.Ech.H. 3431) differs in some aspects from the holotype. For instance the tables of the introvert of the holotype have discs that are slightly smaller and less perforated than those of the complete specimen. However, comparison of the holotype and the other specimens we examined showed that this variation is to be considered intra- rather than interspecific. Nevertheless, we want to note that the second of Sluiter’s (1901) complete specimens (V.Ech.H. 3430, partim) differs slightly from his best preserved specimen described above (V.Ech.H. 3431) in presenting five minute calcareous teeth. However, as the ossicle assemblage of the introvert and tentacles of all of Sluiter’s specimens largely corresponds with that of the type, except for the abundance of ossicles in the tentacles and the presence or absence of rosettes in the longitudinal muscles of the introvert, we conclude that all these specimens are referable to *M. magnum*.

Finally, an important difference between all of Sluiter’s voucher material and the holotype, together with Massin’s voucher materials from Sulawesi (1999) and Papua New Guinea (2005), rests with the banding of the tentacles. Whereas the former shows a more uniform brownish colouration (see also Domantay 1933), the latter show clear banding at the base of the tentacles. There are also some differences in the ossicle assemblage of the muscles of the introvert between the type and Sluiter’s and Massin’s voucher materials: while the type, Massin’s Sulawesi material and two of Sluiter’s specimens did not present these ossicles, two of Sluiter’s Indonesia and both of Massin’s Papua New Guinea specimens did show these. More representative material from the whole distribution range of the species may eventually allow the separation of these slightly different forms which, for now, we retain under *M. magnum*.

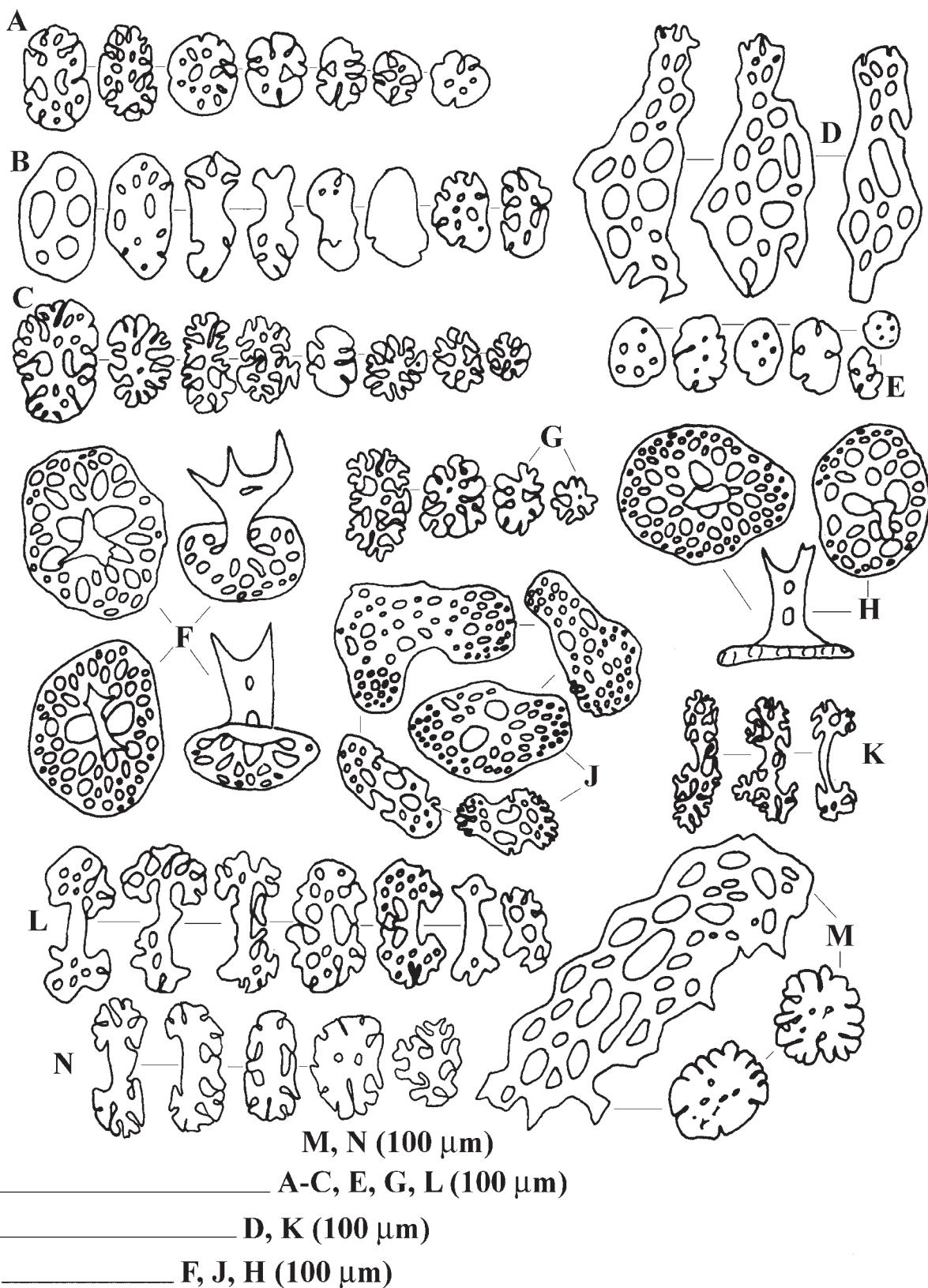
### ***Massinium albicans* sp. nov.**

(figs 5A–M, 6A–F, 7)

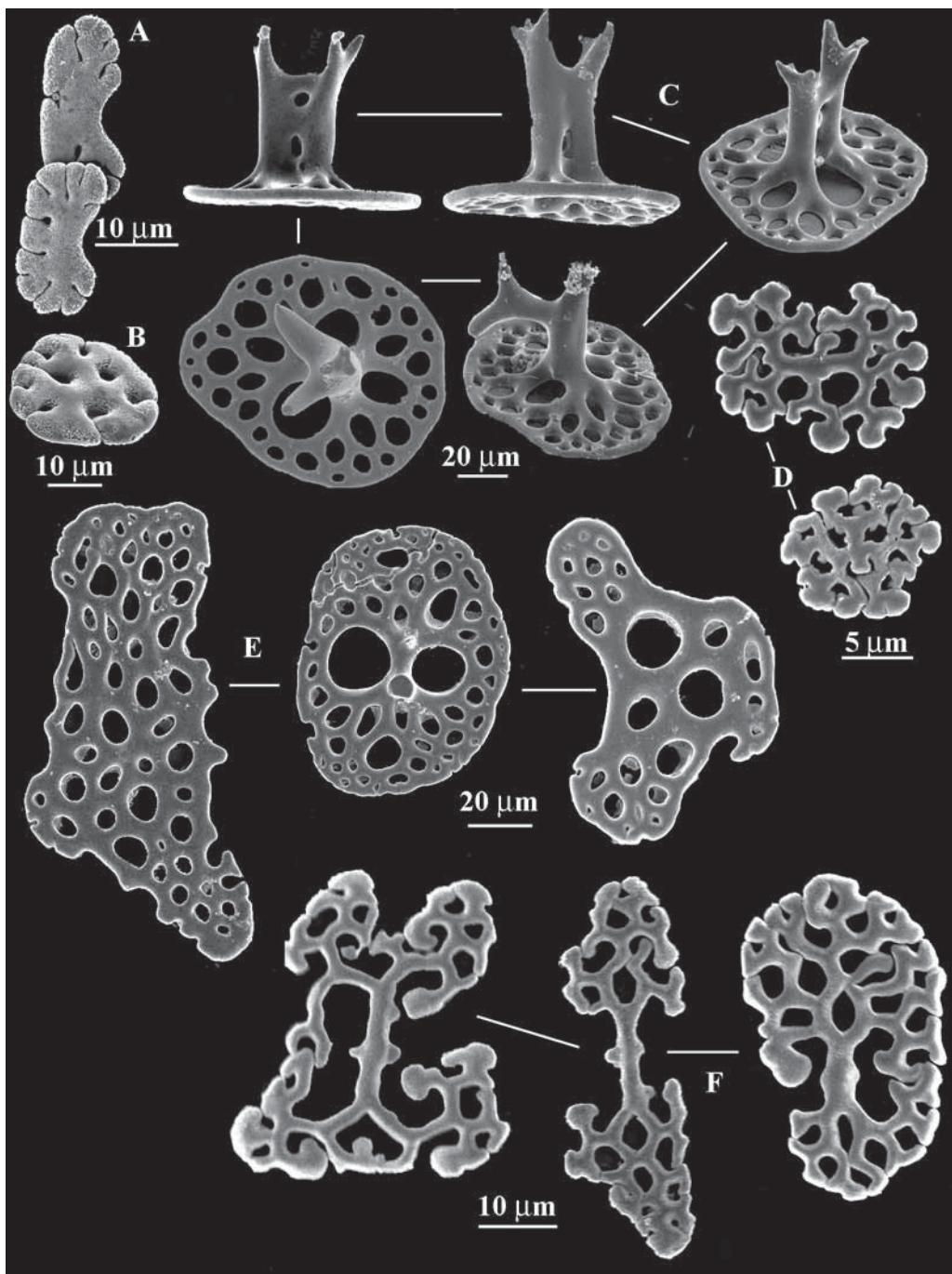
*Neothyonidium magnum*; Cherbonnier 1980: 656, fig 20A–Q; Féral & Cherbonnier 1986: 102, fig. 40T (non *N. magnum*)

**Name bearing type:** Holotype: MNHN EcHh 3096; 2 paratypes MNHN EcHh 3087.

**Type locality:** Chenal Devarenne, New Caledonia.



**FIGURE 5.** *Massinium albicans* sp. nov., Holotype. A. Rosettes and pseudobuttons from anterior body wall; B. Pseudobuttons and rosettes of mid body wall; C. Rosettes of posterior body wall; D. Irregular perforated plates of ventral tube feet; E. Pseudobuttons of ventral tube feet; F. Tables of introvert; G. Rosettes of introvert tube feet; H. Tables of introvert tube feet; J. Perforated plates of introvert tube feet; K. Elongated rosettes of peristome; L. Rosettes of shaft of large tentacle; M. Lattice-like deposit and rosettes of gonoduct; N. Rosettes of longitudinal muscles of cloacal retractor muscles.

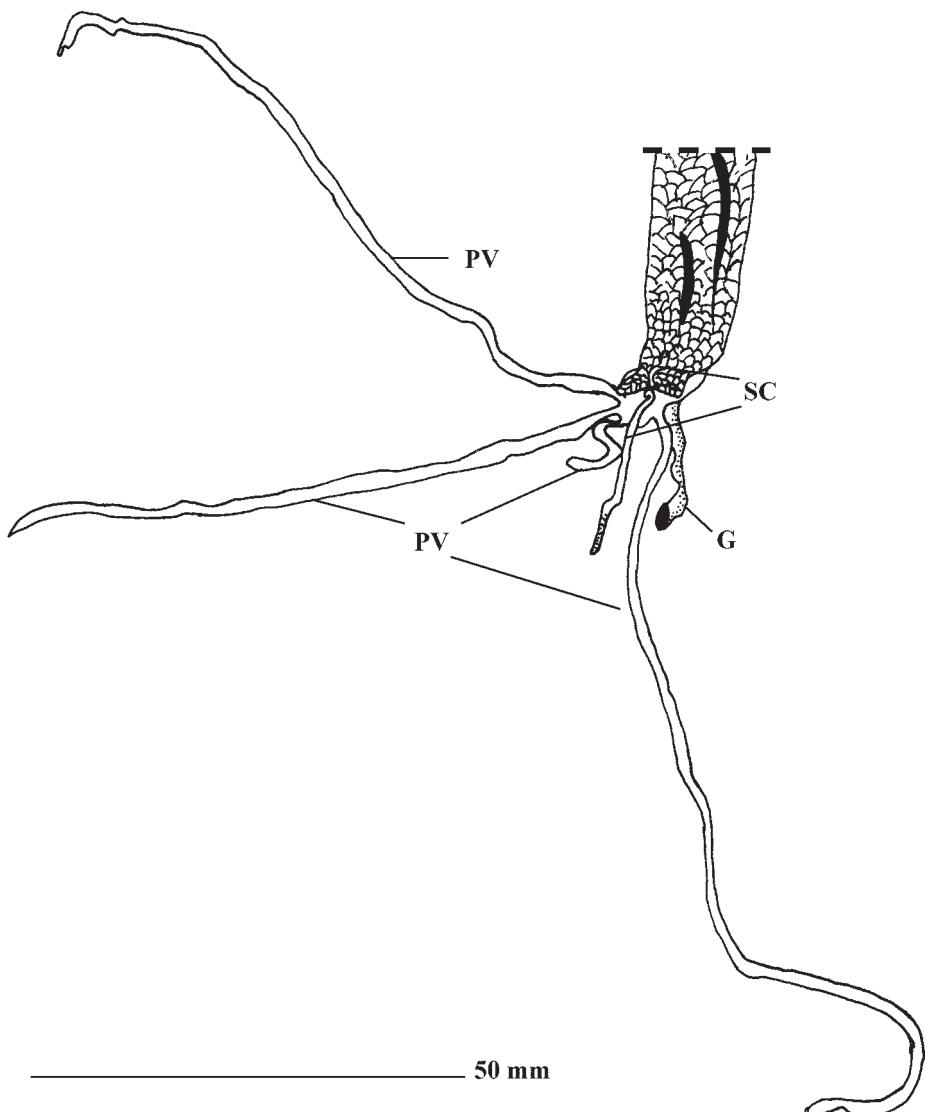


**FIGURE 6.** *Massininium albicans* sp. nov., Holotype. A & B. Pseudobuttons of mid body wall; C. Tables of introvert; D. Rosettes of introvert tube feet; E. Perforated plates and table of introvert tube feet; F. Rosettes of peristome.

**Material examined:** MNHN EcHh 3096 (holotype), Chenal Devarenne (New Caledonia), 15–20 m depth, 1979, coll. Menou; MNHN, EcHh 3087 (2 paratypes), Baie de Canala (New Caledonia), 15–20 m depth, 1979, coll Menou.

**Diagnosis:** Medium-sized, U-shaped species with bloated mid-body with short anterior and long posterior ends. Tables of introvert of two types: those with small ovoid to octagonal disc, perforated by four large and 1–2 small holes alternating with the large ones, and those with more (15–20), small peripheral holes. Introvert tube feet with tables with reduced spire and perforated plates of various shapes and sizes.

**Etymology:** The name *albicans* refers to the yellow-whitish colouration of the body wall and the introvert.



**FIGURE 7.** *Massinium albicans* sp. nov. Holotype. Calcareous ring. (PV=Polian vesicle; SC=stone canal; G=gut).

**Holotype description:** Specimen entire, well-preserved, but calcareous ring detached from introvert due to previous dissection. Body wall firm, rather thick (1–4 mm), slightly rough to the touch. Body form cylindrical, U-shaped, slightly contracted, bloated, with narrow anterior and posterior ends. Introvert well extended, attached to main body. Length of specimen along ventral surface 150 mm; along dorsal surface 75 mm; height of mid-body 50 mm; anterior and posterior ends approximately 35 and 60 mm long; introvert 50 mm long. Colouration of body and introvert yellowish white. Tube feet of body wall yellowish, numerous, small, mostly retracted except on bloated ventral portion, uniformly scattered over entire body, very small suckers. Tube feet of introvert brownish, darker proximally, aligned in radial areas in two well-defined rows, absent in distal 10 mm. Tentacles 20, according to original description, 10 large, 10 small, arranged in two circles; outer tentacles 35–40 mm long, shaft whitish with brownish annulations at base, ramifications blackish; inner tentacles arranged in pairs in the radii, uniform white, 5–8 mm long. Anus small, perhaps surrounded by five (only three counted) small, slender, well calcified teeth, each flanked by a group of terminal podia. Calcareous ring (fig. 7) 70 mm long, tubular with radial and interradial plates fused for five sevenths of the length of calcareous ring, radials prolonged and their processes fused posteriorly, fragmentation of calcareous ring not obvious due to encapsulating thick membrane. Polian vesicles four, three long ones, up to 105 mm (one terminally bifid), and one short, white. Stone canals two, one small, 3.5 mm

long, poorly calcified, the other considerably elongated, 15 mm long, and well calcified, both arising together, each inperceptably merging into the madreporite. Introvert retractor muscles thick and short, originating at anterior third of the body.

**Ossicle assemblage.** Body wall deposits, 15–50  $\mu\text{m}$  long, site dependent: anterior deposits comprise predominantly pseudobuttons and some rosettes (fig. 5A), mid-body wall deposits additionally comprise elongated pseudobuttons with few holes (fig. 5B, 6A&B), posterior deposits comprise mostly rosettes (fig. 5C). Ventral tube feet with irregular perforated plates (fig. 5D) and small, 15–20  $\mu\text{m}$  long, pseudobuttons (fig 5E). Introvert with tables (figs 5F, 6C) and very scarce rosettes of only 20–25  $\mu\text{m}$  long. Tables with round to oval smooth discs, 70–90  $\mu\text{m}$  long, perforated by four central holes of which two are larger than the alternating two, and numerous smaller holes in 2–3 peripheral circles; spire two-pillared, medium to high, with 1–2 cross-bars, terminating in two or more, often diverging, toothed projections. Tube feet of introvert with rosettes, tables and multilocular plates (figs 5G–J, 6D–E). Rosettes simple to complex, 20–40  $\mu\text{m}$  long, open type, with distal endings mostly swollen (fig. 5G, 6D). Multilocular plates of various shapes, 50–150  $\mu\text{m}$  long, with mostly larger central perforations and no branched ends (fig. 5J, 6E). Tables scarce, if present, of introvert type with discs complete, but spire mostly reduced to knobs (fig. 5H, 6E). Peristome with complex, elongated rosettes, 30–60  $\mu\text{m}$  long, with swollen distal endings, often anastamosing (figs 5K, 6E). Shaft and tips of large and small tentacles with deposits similar to those of peristome (fig. 5L). Longitudinal muscles of body wall with rods, rosette-like plates and pseudobuttons. Longitudinal muscles of introvert and of cloacal retractor muscles (fig. 5N) with rosettes only. Gonoduct with rosettes and lattice-like plates (fig. 5M).

Paratypes description (2 complete specimens). Morphology as in holotype. The ossicle assemblage could not be assessed due to preservation in acidic Bouin's fluid which dissolved all the calcareous structures.

**Ecology:** According to Féral and Cherbonnier (1986), this species lives buried in sand or mud on the outer slope of the reef. They further report that in high current environments population density is low, whereas in calmer conditions population density is high and that the species is still visible during the day, but more active during the night. Although listed as rare, the authors report its presence around the whole of New Caledonia, at depths of 3–30 m.

**Remarks:** Cherbonnier (1980) noted that the ossicle assemblage of the introvert of his New Caledonian specimen differs from that described by Sluiter (1901). Cherbonnier (1980) therefore examined the slides prepared by Sluiter and discovered that, in addition to the tables with a small ovoid to octagonal disc, perforated by four large holes and 1–2 small perforations alternating with the large holes, numerous other tables with more (15–20), small peripheral holes were also present in the introvert of his New Caledonian specimen (cf. Cherbonnier 1980: fig. 20 F). Cherbonnier (1980) further noted that the spire of these tables is rather low, ending in four short smooth to spiny points (Cf Cherbonnier 1988: fig. 20K). However, in Sluiter's preparations he failed to locate tables that have their disc and spire similar to those he illustrates (cf. Cherbonnier 1980: figs 20 F,J,L,N). He correctly questioned if his, Sluiter's or Domantay's (1933) records are the true *N. magnum*. After examination of the holotype, he concluded that the tables in the introvert of his material correspond best with the holotype.

We disagree with Cherbonnier's (1980) decision because the tables in the New Caledonia material, here described as a new species, have their discs perforated with more holes and show the spires terminating in pronounced tooth-like projections. Moreover, we note there is a marked difference in the plate-like deposits of the introvert tube feet of the two species. While those of *M. magnum* are highly irregular with their terminal ends branched (figs 1C, 2C), those of *M. albicans* are more regular, never with branched terminal ends, and with much more smaller perforations (figs 5J, 6F). Moreover, the peristomial deposits in both species vary considerably (cf. figs 1D, 2D with figs 5K, 6F). Lastly, the colouration of the introvert of *M. albicans* and *M. magnum* is markedly different (cf. Massin 1999, fig 113a with Cherbonnier & Féral 1986: 103).

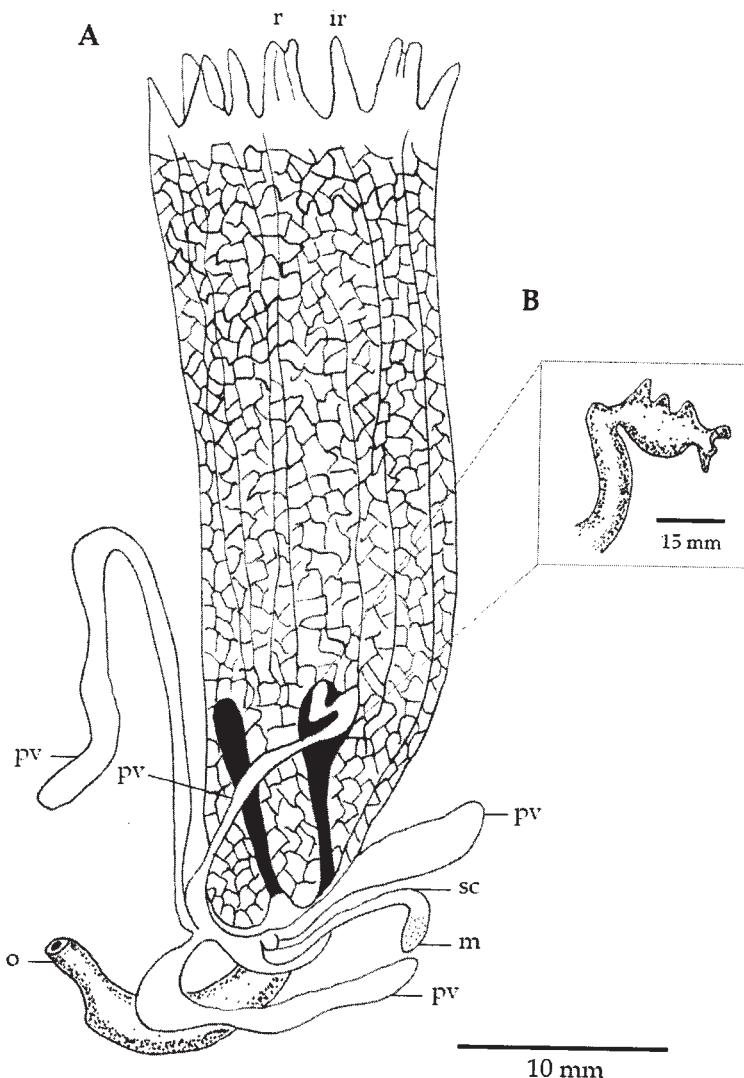
*M. albicans* is perhaps endemic to New Caledonia.

**Massinium granulosum sp. nov.**  
(figs 8 A,B ; 9 A–E, 10A–C, 11 A–F)

**Name bearing type:** Holotype: AMS: J13578.

**Type locality:** Dunwhich (Stradbroke Island, Moreton Bay, Queensland, Australia)

**Material examined:** AMS J 13578 (holotype + paratype, identified as *Neothyonidium magnum* by F.W.E. Rowe), Dunwhich (Stradbroke Island, Moreton Bay, Queensland, Australia), intertidal, 14.xi.1977, coll. H. Silver.

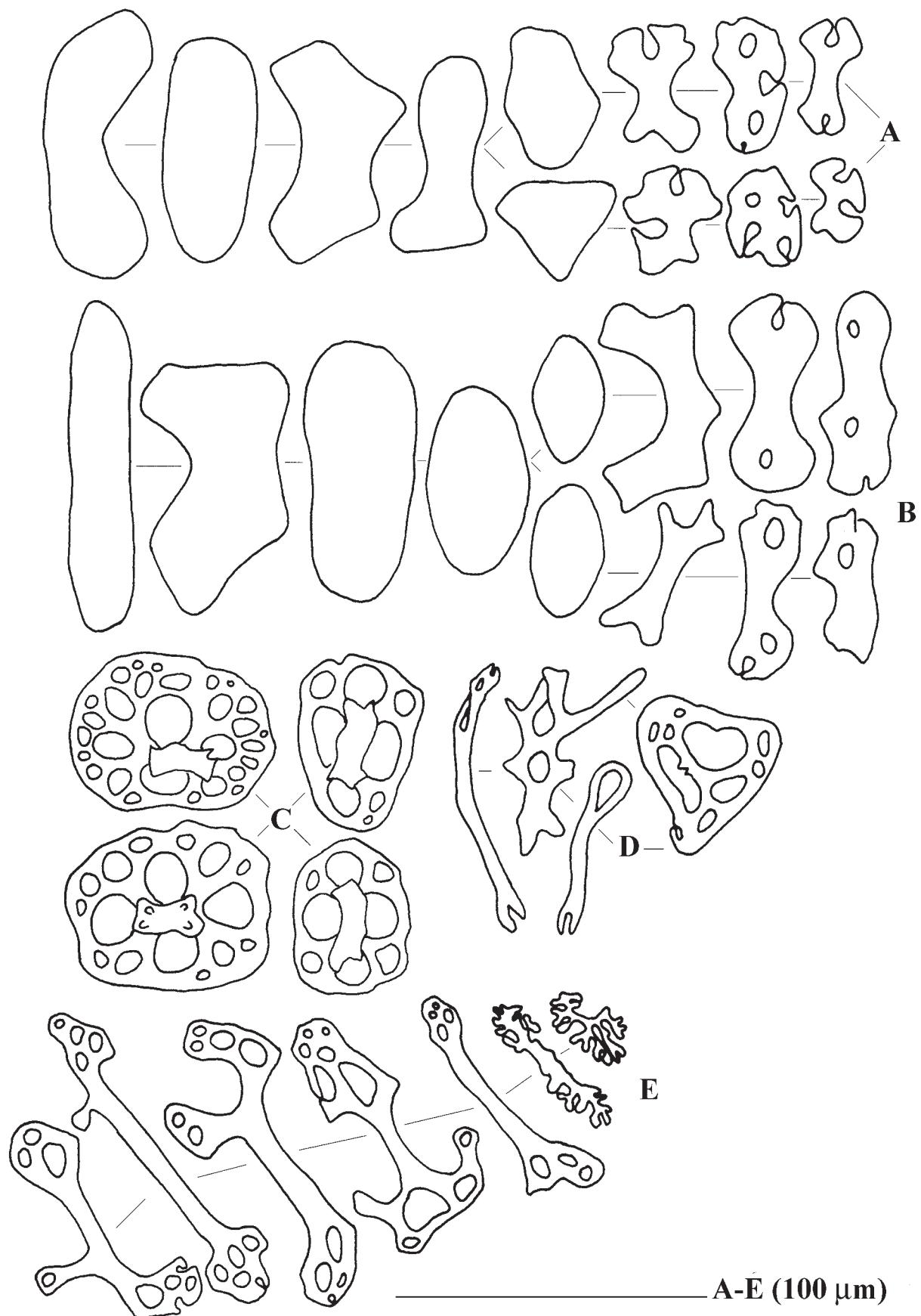


**FIGURE 8.** *Massinium granulosum* sp. nov., Holotype. A. Calcareous ring; B. Terminal end of the Polian vesicle that is embedded in the calcareous ring. (pv=Polian vesicle; r=radial plate; ir=interradial plate; sc = stone canal; m=madreporite).

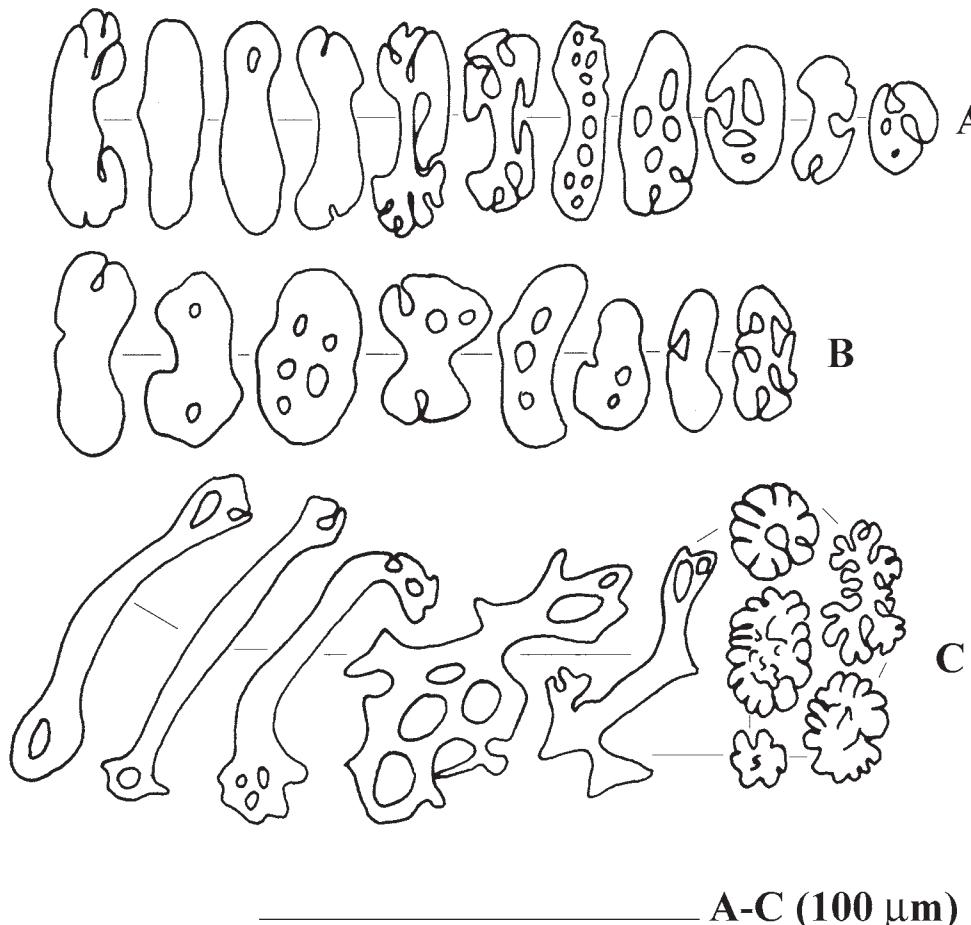
**Diagnosis:** Small-sized, U-shaped species, with slightly bloated mid-body with narrow anterior and posterior ends; body wall deposits granuliform, rarely perforated rods.

**Etymology:** The name *granulosum* refers to granuliform rods of the body wall.

**Holotype description:** Specimen well-preserved, calcareous ring and associated structures detached, but still linked to main body by introvert. Body wall firm, but not thick (2–3 mm), slightly rough to the touch. Body form cylindrical, U-shaped, slightly twisted, slightly bloated mid-ventrally with narrower anterior and posterior ends. Length along ventral surface 130 mm; length along dorsal surface 90 mm; height of mid-body about 30 mm; anterior and posterior ends respectively 15 and 10 mm long; introvert approximately 25 mm



**FIGURE 9.** *Massinium granulosum* sp. nov., Holotype. A Granuliform rods and pseudobuttons of ventral body wall; B. Granuliform rods and perforated rods from dorsal body wall; C. Tables of introvert; D. rods and plate-like deposits of introvert tube feet; E. Rosettes and perforated rods of peristome.



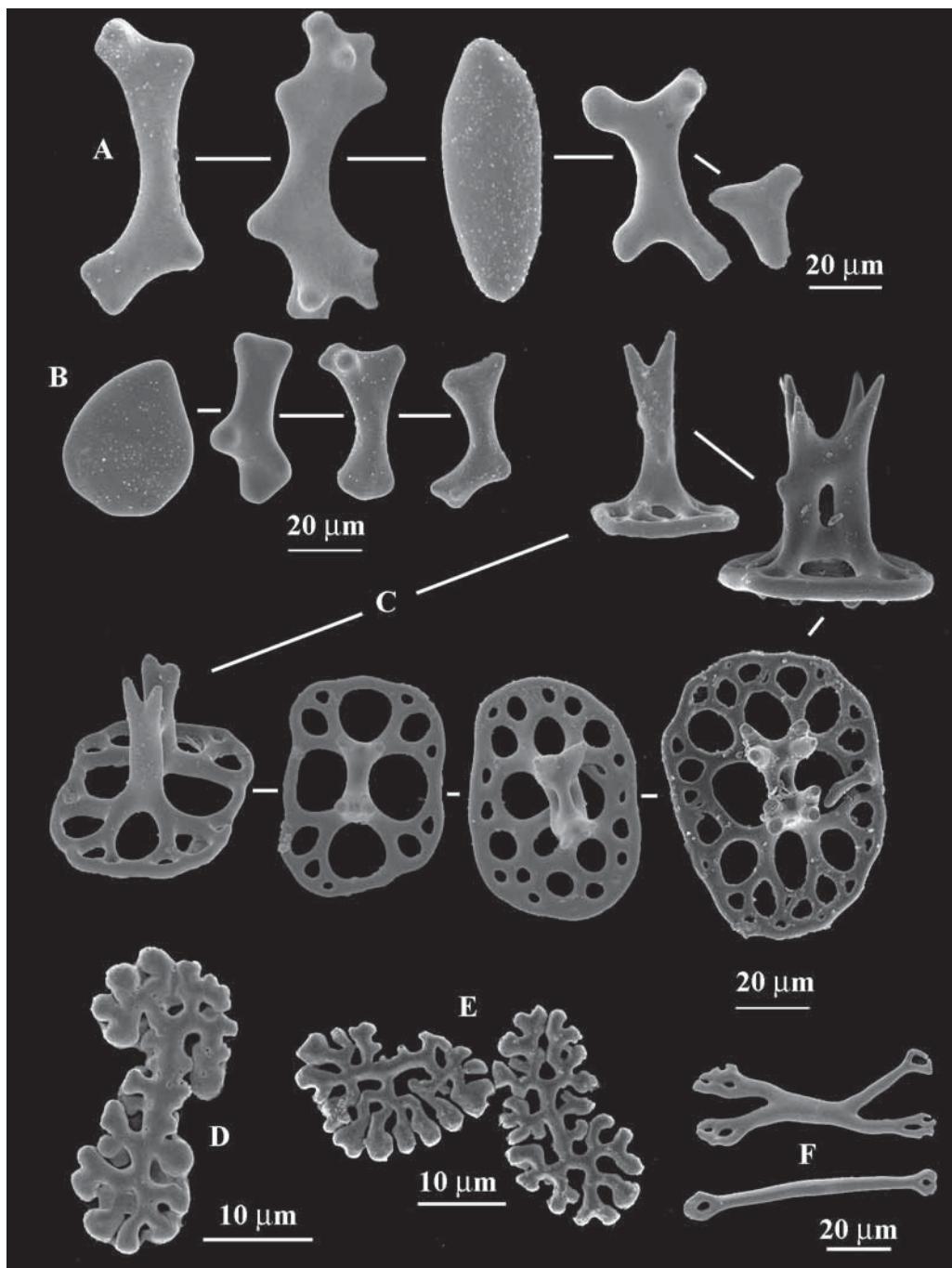
**FIGURE 10.** *Massinium granulosum* sp. nov., Holotype. A. Rods and pseudobuttons of longitudinal muscles of body wall; B. Pseudobuttons of cloacal retractor muscles; C. Perforated rods, plate-like deposit and rosettes of anal papillae.

long. Anterior and posterior body wall with series of slits in interradial areas. Colouration of body yellowish white, slightly paler mid-ventrally; introvert yellowish white. Tube feet of body wall retracted, numerous, small, scattered over entire body, suckers minute, beige. Tube feet of introvert scarce, restricted to the most proximal part, in the radii, in one to two rows. Tentacles 20, in two circles, outer circle of 10 large (only seven intact), inner circle of 10 small alternating in pairs with large ones; outer tentacles 25–40 mm long, shaft yellowish brown without visible annulations, ramifications dark brown; inner tentacles about 5 mm long, colour as in large tentacles. Anus small, surrounded by five minute teeth, quite deciduous, each flanked by several brownish papillae situated in distinct triangular dispositions. Calcareous ring (Fig. 8A) 40 mm long, tubular, with radial and interradial plates fused for three quarters of length of calcareous ring, radials posteriorly prolonged, bifurcating, with processes fused to those of neighbouring plates; radial plates with deep anterior notch; interradial plates anteriorly pointed; fragmentation of calcareous ring not obvious due to thick encapsulating membrane.

Polian vesicles four, one sacciform, three tubular, elongated, up to 35 mm long, with tip of one of the latter, deformed and lying in a posterior slit of calcareous ring (fig. 8A & B). Stone canal single, poorly calcified, about 9 mm long, merging imperceptably into ovoid madreporite. Introvert retractor muscles thin and short, originating from anterior end of longitudinal muscles.

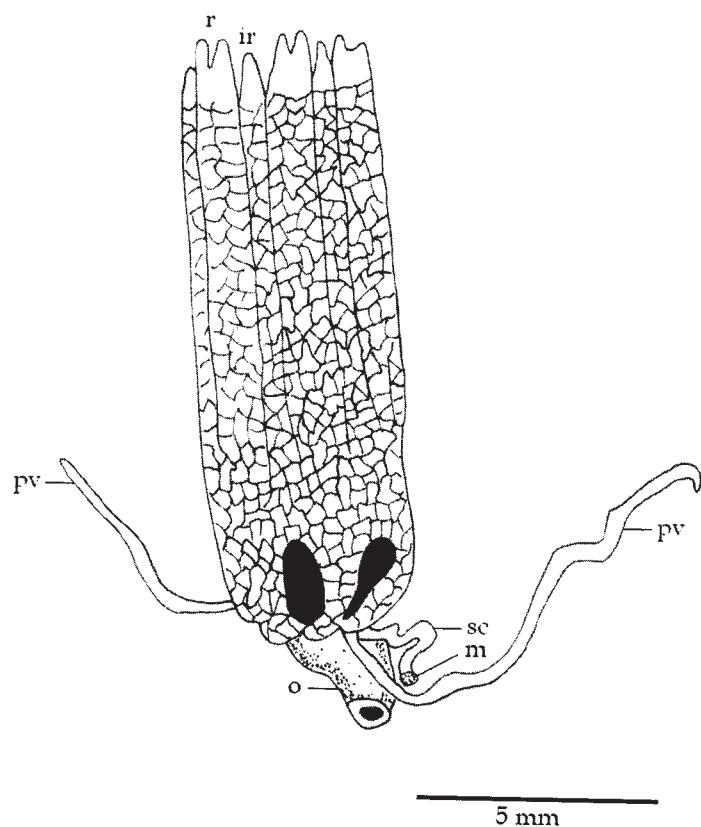
*Ossicle assemblage.* Dorsal and ventral body wall deposits identical, comprising irregular pseudobuttons and granuliform, rarely perforated rods of various shapes, 25–105 µm long (figs 9A,B; 11 A,B). Introvert with tables only; table disc ovoid, smooth, perforated by four large central holes and smaller holes alternating with

these, in 1–2 peripheral circles; spire two-pillared, medium height, 50–75  $\mu\text{m}$  high and 35–50  $\mu\text{m}$  wide, with single cross-bar, terminating in 2–4 toothed projections (fig. 9C, 11C). Tube feet of introvert with endplate surrounded by slender and plate-like perforated rods (fig 9D). Peristome with elongated rosette-like rods, 30–50  $\mu\text{m}$  long, and other elongated rods, swollen terminally and perforated, 70–110  $\mu\text{m}$  long (fig. 9E, 11D). Large tentacles devoid of ossicles. Shafts and tips of small tentacles with complex, closed rosettes only (fig. 11E). Longitudinal muscles of body wall with pseudobuttons and elongated granuliform rods, 22–50  $\mu\text{m}$  long (fig. 10A). Anal papillae with elongated slightly curved rods, terminally expanded and perforated, 45–90  $\mu\text{m}$  long (fig. 10C, 11F), and few closed rosettes, 15–35  $\mu\text{m}$  long (fig. 10C). Cloacal retractor muscles with pseudobuttons (fig. 10B).



**FIGURE 11.** *Massinium granulosum* sp. nov., Holotype. A. Granuliform rods of ventral body wall; B. Granuliform rods of dorsal body wall; C. Tables of introvert; D. Rosette of peristome; E. Rosettes of tip of small tentacle; F. Perforated rods of anal papillae.

**Remarks.** Thandar (1989) described the South African endemic *Massinium arthroprocessum* (Thandar, 1989) from False Bay and in 1996 recorded the species also from Durban. In his publication, Thandar (1989: 643) stated that Rowe advised him that ‘an undescribed, similar but not identical form occurs in Queensland (Australia)’. Upon re-examination of Australian voucher material, identified as *Neothyonidium magnum* by Rowe, we came across the species Rowe probably implied. It is this species that is here described as new and is clearly sister to the South African form by the presence of characteristic slits in the body wall and simple body wall deposits. However, the South African *M. arthroprocessum* and the Australian *M. granulosum* differ clearly from each other in the following four characteristics: (i) body wall colouration in alcohol of *M. arthroprocessum* is grey speckled with reddish brown, whereas that of *M. granulosum* is uniform yellowish-white; (ii) the body wall ossicles are mostly U shaped rods with terminal perforations in *M. arthroprocessum*, whereas they are more granuliform, seldom perforated and of greater variety in *M. granulosum*; (iii) tentacle deposits in *M. arthroprocessum* comprise slender elongated rods bearing a single perforation at each ending, whereas in *M. granulosum* only rosettes are present and then only in the small tentacles; (iv) introvert deposits of *M. arthroprocessum* comprise tables, rods and rosettes, whereas those of *M. granulosum* tables only.



**FIGURE 12.** *Massinium dissimilis* (Cherbonnier, 1988). Calcareous ring of holotype (pv=Polian vesicle; r=radial plate; ir=interradial plate; sc = stone-canal; m=madreporite.; o= oesophagus).

## Discussion

In 2003, Samyn & Thandar called for a revision of *Massinium magnum* (Ludwig, 1882) because they suspected this taxon either to be ‘highly variable’ or a ‘species complex’. The second option proved to be the case whereby two new species are here recognised. The reason why these two species remained hitherto undiscovered most probably lies in the fact that the holotype of *Massinium magnum* consists only of the anterior fragment which was incompletely, incorrectly and inadequately described. We considered requesting the Commission of Zoological Nomenclature to set aside under its plenary powers the existing name-bearing

type and designate a neotype (cf Art 75.5). However, because several specimens have in the past been correctly assigned to *M. magnum* (e.g. by Sluiter in 1901 and Massin in 1999), this species cannot be treated as a *nomen dubium* and does not qualify for neotype designation.

To our knowledge nobody has yet examined the ossicle assemblage of the gonoduct in holothuroids. Such was possible in the present work because the gonoduct is unusually conspicuous in *M. magnum* and *M. albicans*, but regrettably not in *M. granulosum*. Given that the ossicle assemblage of the gonoduct seems quite distinctive, it is here advised that its study be included in future taxonomic descriptions, where possible.

## Acknowledgments

It is with pleasure that we thank the many people who have helped in making voucher material available. In particular we want to express our gratitude to Dr P. Berents of the AM; Dr N. Cominardi of the MNHN, Dr B.W. Hoeksema of the NMNH, Dr Cl. Massin of the RBINS and Dr J. Bleeker of the ZMA. The Belgian National Focal Point to the Global Taxonomy Initiative is warmly thanked for its financial and logistic support to YS and AST. The National Research Foundation (South Africa) is thanked for its generous support to AST. Finally, we thank Dr. Cl. Massin of the RBINS for critically reviewing an earlier draft of this manuscript, as well as two anonymous referees for their valuable comments.

## References

Cherbonnier, G. (1980) Holothuries de Nouvelle-Calédonie. *Bulletin du Muséum National d'Histoire Naturelle de Paris* 4ème série 2, section A(3), 615-667.

Cherbonnier, G. (1988) Echinoderms: Holothurides. *Faune de Madagascar* 70, 1-292.

Clark, A.M. & Rowe, F.W.E. (1971) *Monograph of shallow-water Indo-West Pacific echinoderms*. Trustees of the British Museum of Natural History London, 238 pp, 31 pls

Clark, H.L. (1938) Echinoderms from Australia. *Memoirs of the Museum of Comparative Zoology, Harvard* 55 (8), i-viii, 1-596, pls 1-28.

Colin, P.L. & Arnison, Ch. (1995) *Tropical Pacific Invertebrates. A Field Guide to the Marine Invertebrates Occurring on Tropical Pacific Coral Reefs, Sea Grass Beds and Mangroves*. Coral Reef Press, Beverly Hills, i-viii, 1-296.

Deichmann, E. (1938) Eastern Pacific Expeditions of the New York Zoological Society. XVI. Holothurians from the Western Coasts of Lower California, and from the Galápagos Islands. *Zoologica New York*, 23, 361-387.

Domantay, J.S. (1933) Littoral Holothuroidea of Port Galera Bay and Adjacent Waters. *Natural Applied Science Bulletin, University Philippines*. 3, 41-101, pls 1-4.

Domantay, J.S. (1936) The ecological distribution of the echinoderm fauna of the Puerto Galera Marine Biological Station. *Natural Applied Science Bulletin, University Philippines*. 5: 385-403, pls 1-7.

Erhardt H.A., & Moosleitner, H. (1997) *Meerwasser Atlas Bd 3 Wirbellose Tiere*. Mergus Verlag, Melle, 738-1328.

Féral, J.-P. & Cherbonnier, G. (1986) Les holothurides. In: Guille, Laboute & Menou (eds), *Guide des étoiles de mer, oursins et autres échinodermes du lagon de Nouvelle-Calédonie*, ORSTOM, Paris, 55-107.

Forbes, R., Ilias, Z., Baine, M. Choo, PS., & Wallbank, A. (1999) *A Taxonomic key and field guide to the sea cucumbers of Malaysia*. Heriot-Watt University, Stromness, 62 pp.

George, J.D. & George, J. (1987) The corals of the Bodgaya Islands (Sabah: Malaysia) and Pulau Sipadan. *Malayan Nature Journal* 40, 225-260.

Gosliner, T.M., Behrens, D.W. & Williams, G.C. (1996) *Coral Reef Animals of the Indo-Pacific: animal life from Africa to Hawaii exclusive of the vertebrates*. Sea Challengers, Monterey, 314 pp.

Heding, S.G. & Panning, A. (1954) Phyllophoridae. Eine Bearbeitung der Polytentaculaten Dendrochiroten Holothurien des Zoologischen Museums in Kopenhagen. *Spolia Zoologica Musei Hauniensis*, 13, 1-209, figs 1-102.

Lampert, K. (1885) Die Seewalzen. Eine systematische Monographie. In: Semper, C. (Ed.), *Reisen im Archipel der Philippinen, Teil 2, Wissenschaftliche Resultate*. Wiesbaden, 1-310, 1 pl.

Lane, D.J., Marsh, L.M., VandenSpiegel D., Rowe, F.W.E. (2000) Echinoderm fauna of the South China Sea: an inventory and analysis of distribution patterns. *The Raffles Bulletin of Zoology*, Supplement 8, 459-493.

Ludwig, H. (1882) List of the holothurians in the collection of the Leyden Museum. *Notes Leyden Museum*, 4(10), 127-137.

Ludwig, H. (1889-1892) Echinodermen: Die Seewalzen. In: Bronn, H.G. (Ed.), *Bronn's Klassen un Ordnungen des*

*Their-Reichs, wissenschaftlich dargestellt in Wort und Bild.* CF. Winter'sche Verlagshandlung, Leipzig, 460 pp., 17 pls.

Massin, C. (1999) Reef-dwelling Holothuroidea (Echinodermata) of the Spermonde Archipelago (South-West Sulawesi, Indonesia). *Zoologische Verhandelingen*, 329, 1-144.

Massin, C. (2005) New records of Dendrochirotida (Echinodermata: Holothuroidea) from Papua New Guinea. *Bulletin de l'Institut royal de Sciences naturelles de Belgique: Biologie* 75, 61-80.

Oestergren, H. (1907) Zur Phylogenie und Systematiek der Seewalzen. In: Sartryck Ur Zoologiska Studier Tillägnade T. Tullberg På Hans 65-års Dag. Almqvist et Wiksell, Uppsala, 191-215.

Rowe, F.W.E. & Doty, J.E. (1977) The Shallow-Water Holothurians of Guam. *Micronesica* 13, 217-250.

Rowe, F.W.E. & Gates, J. (1995) Echinodermata. In: Wells, A. (Ed.), *Zoological Catalogue of Australia*. CSIRO Australia, Melbourne, vol. 33, i-xiii, 1-510.

Samyn, Y. & Thandar, A.S. (2003) *Massinium*, a new genus in the family Phyllophoridae (Echinodermata: Holothuroidea: Dendrochirotida) with description of a new south-west Indian Ocean species *Massinium maculosum*. *Belgian Journal of Zoology* 133, 132-142.

Sluiter, C.P. (1901) Die Holothurien der Siboga Expedition. *Siboga Expedition*, 44, 1-142, 10 pls.

Thandar, A.S. (1989) A new species of a phyllophorid holothurian from southern Africa. *Journal of Zoology, London*, 219, 637-644.

Thandar, A.S. (1996) *Chiridota durbanensis* new species and a new record of *Neothysonidium arthroprocessum* from the east coast of South Africa (Echinodermata: Holothuroidea). *South African Journal of Zoology*, 31, 208-213.

Théel, Hj. (1886) Holothuroidea. Part 2. *Results of the Voyage of the Challenger (Zoology)* 39, 1-290, pls 1-16.

## Appendix. Museum acronyms

AM	Australian Museum, Sydney, Australia
MNHN	Muséum National d'Histoire Naturelle, Paris, France
NMNH	National Museum of Natural History (Naturalis), Leiden, the Netherlands
RBINS	Royal Belgian Institute of Natural Sciences, Brussels, Belgium
ZMUA	Zoologisch Museum van de Universiteit Amsterdam, Amsterdam, The Netherlands